Science Arena Publications
Specialty Journal of Engineering and Applied Science
ISSN: 2520-5943
Available online at www.sciarena.com
2020, Vol, 5 (2): 9-18

Investigation of rainfall temporal distribution patterns

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Abstract: *Precipitation is one of the important elements of climate and is one of the factors affecting the hydrological cycle. The amount of rainfall per unit of time is called the intensity of precipitation. During the rainfall, the intensity of precipitation is not constant and varies with time. Consideration of the persistence of precipitation in the temporal pattern depends on the physiographic characteristics of the basin and especially the reaction time of the system to rainfall. Further design of engineering facilities requires a comprehensive understanding of the extent of atmospheric precipitation moreover temporal distribution. The application of temporal distribution patterns of precipitation increases the accuracy of hydrological simulation of watersheds. One of the most important factors in preparing and developing a hydrological model of watersheds is understanding the temporal distribution of precipitation. Construction of dams and water installations requires extensive hydrological studies to develop water and soil designs and to supply potable and agricultural water. Some of these studies are for estimating and predicting floods and sediments that are that are very importance in reservoir design and dam overflow. One possible way to estimate a design flood in a basin is to use rainfall statistics in design rain selection. Design rain is characterized by several features such as: total amount of rain, total persistence, time distribution of rain, introduced and characterized. The temporal distribution pattern of precipitation, which is actually how the intensity of precipitation changes during rainfall, has a direct impact on the volume and flow rate of the flood peak and sediment volume. Numerous methods have been used in the temporal distribution of precipitation, including the methods of non-dimensional, triangular, intensity-duration-frequency, pilgrim, statistical distributions, SCS type and Huff models.*

Keywords: *Temporal distribution of precipitation, Dimensional cumulative curves, Triangular, Pilgrim, Statistical distributions*

INTRODUCTION

Precipitation is one of the important elements of climate and is one of the factors affecting the hydrological cycle. Rainfall on the surface of the earth has many spatial and temporal variations. The average rainfall at the Earth's surface is estimated at between 700 and 900 mm. But changes in rainfall on the surface of the earth are such that some deserts may not have received any rainfall in a few consecutive years. In general, the precipitation on the oceans is high and the annual precipitation will decrease as they depart. According to one general rule, the drier the climate, the lower the confidence in atmospheric precipitation. Extreme variability and fluctuations in rainfall in arid and semi-arid regions, including the Iranian plateau, are by no means unexpected. In terms of latitude and proximity to the high-pressure subtropical front, in addition to the lack of rainfall Iran also has high fluctuation rainfall regime. Low annual rainfall, severe annual and seasonal fluctuations, shortening of rainfall period, and falling precipitation as severe and sudden thunderstorms are characteristic of the Iran rainfall regimes (Teimouri and Bazrafshan, 2017). Precipitation is not uniform during the rainfall. The temporal distribution pattern of rainfall actually illustrates how rainfall intensity changes over a period of rainfall that have a direct impact on the volume, peak flood discharge, and discharge time. As in some thunderstorms, the maximum intensity of precipitation occurs early in others, while others occur in the middle or late stages of thunderstorms, depending on the mechanism of precipitation formation. Due to the processes of runoff formation at the basin level, each of these patterns causes a specific form of flooding (Hatami et al., 2009). mostly, important in watershed studies, river bank management, civil engineering and hydraulic installations in rivers, dam construction, soil conservation, a thorough and comprehensive understanding of the two characteristics of the amount and temporal distribution of rainfall (Hatami et al., 2009). Further design of engineering facilities requires a comprehensive understanding of the extent of atmospheric precipitation moreover its temporal distribution. Design flood estimation is one of the important components of hydrology studies of water resources projects, especially dam designs and hydraulic installations, which are performed in different ways. Mathematical models for converting design rain to design flooding are a common option in cases where significant system storage capacity or design flood recovery periods are long. The first step in estimate designing floods is to choose design storm. This design rain is characterized by several characteristics such as total persistence, total amount and temporal distribution of precipitation. The total amount of design rain is determined based on the degree of safety required, the total continuity being selected according to the geographical features of the basin and the moderating power or storage capacity of the basin. An appropriate model should be used to determine the temporal distribution of rainfall during the design. This pattern determines how rainfall falls during rainfall (Ramezani et al., 2017). Flood estimation is the main design important in the construction and design of hydraulic structures. Rain has its own characteristics such as quantity, persistence and time distribution (Ramezani et al., 2017). The study of precipitation in two parts, space and time, each tells the facts of the climate so that the results obtained will be different by keeping one component constant. Understanding how rainfall behaves and conforms to pre-researched patterns and models can therefore be of great help in designing environmental projects, whether structural, etc. The application of temporal distribution patterns of precipitation increases the accuracy of hydrological simulation of catchments. One of the most important factors needed in preparing and developing hydrological model of catchments is understanding the temporal distribution of precipitation (Zabihi et al., 2012). Currently, in Iran, due to insufficient information on the distribution of project rainfall, most of the templates provided by the American Soil Conservation Service (SCS) or other external sources are used, which is likely to be incompatible with Iran climate (Radmanesh et al., 2007). The purpose of this study is to investigate the methods of determining the time distribution pattern of precipitation.

Research Method

The research method in this study is descriptive. In order to carry out this research by documentary method, information was prepared, analyzed and combined. At the documentary stage, information is collected, studies, publications, information from specialized books on methods of determining the temporal distribution pattern of precipitation and internet sites.

Discussion

Further design of engineering facilities requires a comprehensive understanding of the extent of atmospheric precipitation moreover their temporal distribution. Application of temporal precipitation patterns increases precision in hydrological simulation of watersheds. One of the most important factors in preparing and developing a hydrological model of watersheds is the knowledge of precipitation time distribution. Construction of dams and water installations requires extensive hydrological studies to develop water and sewage schemes and to supply potable and agricultural water. Some of these studies are for estimating and predicting floods and sediments that are very importance in reservoir design and dam overflow. One possible way to estimate a design flood in a basin is to use rainfall statistics in design rain selection. Design rain is characterized by several features such as: total amount of rain, total persistence, time distribution of rain, introduced and characterized. The temporal distribution pattern of precipitation, which is actually how the intensity of precipitation changes during rainfall, has a direct impact on the volume and discharge of the flood peak and sediment volume (Jahanbakhsh Asl et al., 2015). The temporal variability of rainfall has been extensively studied around the world, and as computers have become steadily faster, more possibilities have been provided to account for such temporal variations (Mafakheri et al., 2017). There has been a great deal of research and study on the temporal distribution of rainfall and the determination of the time distribution pattern at different time points in different parts of the world. Numerous methods have been used in the temporal distribution of precipitation, including the methods of non-dimensional, triangular, intensity-duration-frequency, pilgrim, statistical distributions, SCS type and Huff models.

- **Dimensionless method**

One of the studies on rainfall temporal distribution relates to Huff (1967), that by dividing the 11-year precipitation at 49 rain gauge stations by the first to fourth quartile based on the maximum precipitation in each quartile and determining the frequency of occurrence, the final probabilistic time distribution pattern. With 10-90% probability levels for 261 rainstorms (ranging from 3 to 48 hours) recorded in an area of 1032 km^2 east of the state of Illinois in the form of cumulative curves, resulting in 42% of the rains being less in the persistence group of the 12 hours, 33% in the 12-24 hours' continuation group and the other 25% in the continuation group were located durations longer than 24 hours Pilgrim and Cordery (1975) presented a temporal distribution pattern of precipitation in Sydney, Australia using 50 intense storms with different time bases over a 51-year statistical and computational approach. They set up rainfall patterns in Australia by selecting intense storms and determining the cumulative percentage of the time distribution of precipitation. In this method, first the appropriate rainstorms were selected and then classified according to the desired time bases and plotted the rainfall time for each specific continuum against the cumulative percentage of rainfall amount on the coordinate axes. Since there is usually more than one thunderstorm in each continuum, the average rainfall amount was obtained and the mean curve was considered as the temporal pattern of rainfall distribution in that time period to select the appropriate temporal pattern. Loukas and Quick (1996) studied the temporal and spatial distribution of rainfall in southwestern Columbia country. The method used by Hoff was adopted in this study, and 175 rainstorms in variable continuity were used to determine the dimensional ones and the curves obtained for different probabilities were determined. According to Loukas and Quick, in many cases the use of an intermediate temporal distribution would be appropriate. In other cases, however, a time distribution curve with a probability of 10 or 90% may be used because such a distribution may maximize runoff. There is only one difference between this study and the Huff method, which is that the Loukas and Quick curves are not classified by most quartiles. In the Huff data for the Illinois area, about 67 percent of the rainfall events were thunderstorms, causing Huff to divide the storms by the quartile method, but in this study and in the Columbia region, most storms were generated by frontal systems even in summer. These low- to moderate-intensity frontal rainfall and long-term continuities create a more uniform rainfall pattern, and therefore no need for storms to be classified by quartz. The time distribution of 175 storms analyzed was determined for all stations at different altitudes. Ocular examination of the curves of 10, 50 and 90 percent and applying the Kolmogorov-Smirnov test showed that there was no significant difference between the curves except for the 90% curve for Vancouver Harbor (base station) that The Vancouver Harbor 90% curve was deviated from the other curves. However, the Kolmogorov-Smirnov test showed no significant difference between the curves of each station at the 20% level. Therefore, altitude and topography have had a great effect on rainfall and persistence, but have very little effect on temporal distribution. In this study, probabilistic curves of time distribution after storms were classified into different types of events for each class. For example, all events in Vancouver Harbor were rain events and at another station called S-1 only 7 were snow events and 4 were snow and rain events. Also at station B_{25}, there were 44 snowstorms like snow, 35 events snow and rain and 96 more events like they were raining in summer and winter. Comparison of B_{25} station curves to study the effect of different events on the temporal distribution of rainfall. Comparison of 10, 50 and 90% curves and application of Kolmogorov-Smirnov test at 20% level for different types of events showed no significant differences for different types of events. It was concluded that the effect of the event type was minimal for the time distribution of the storms. To investigate the effect of depth and persistence of storm on temporal distribution of station S-1 storms were selected and groups of storms with continuities less than 24 hours, between 24 and 48 hours and greater than 48 hours were considered. Determination of 10, 50 and 90% curves showed that the persistence of the storm had little effect on the temporal distribution pattern of the storms. They performed a similar method to determine the effects of total rainfall and applied design storm groups of less than 50.8 mm, between 50.8 and 101.6 mm and larger than 101.6 mm. Eye observation showed that the temporal distribution was not affected by the total amount of rainfall. The Kolmogorov-Smirnov test also showed that there was no significant difference between each curve of each continuity and the amount of storms. Finally, Loukas and Quick concluded that this series of curves can be used based on the mean of all storms at all altitudes. The temporal distribution of this study was compared with those obtained for the Seymour Basin with similar climatic regimes in British Columbia. In this regard, three stations located at different levels of British Columbia were selected to develop probability curves of the time distribution pattern. The time distribution curves obtained using the data from these three stations were compared with the mean time distribution curves obtained in the Seymour River Basin. The comparison showed that the curves of the three British Columbia stations were similar. Loukas and Quick thus concluded that the curves developed for the Seymour Basin could be valid throughout the British Columbia region. They believe that if the difference in the probability curves of the rainfall time distribution pattern does not significantly affect the simulation of the basin response, the user can use these curves more confidently. De Luıs et al (2000) used 97 rain gauges during the 1961–1990 statistical period to investigate the spatial and temporal characteristics of precipitation in the Valencia region, west of the Mediterranean. In this study, kriging interpolation method was used and the results showed that in very humid regions there is a significant decrease in annual rainfall. In the inner regions, the total annual rainfall has also decreased. Changnon (2003) examined the temporal distribution of precipitation in the western Illinois state during the 20th century. The results show that between 1928 and 1942, 98 percent of rainfall was below the region's average. During the years 1958 to 1972, rainfall was closer to normal in the region and during 1973 to 2002 the weather was extremely poor. During these years, precipitation was about 91 percent higher than the region's average. Back (2011) investigated the temporal distribution pattern of precipitation in the Brazilian Santa Catarina region. In this study, the graphs years 1980 and 2007 meteorological stations have been used for minutely recorded. Using a Delphi language, they developed a computer program to manage, select, and classify heavy rainfall events, and separated individual rainfall by a minimum of 6 hours without precipitation, and used the Relationship 1 to select heavy precipitation. According to this method, precipitation with minimum P_{min} is classified as heavy rainfall:

$$P_{min} = 8.9914D^{.2466} \quad (1)$$

Which in the formula:

P_{min}: minimum precipitation in mm
D: duration of rainfall per minute
Back et al. (2011) by using the Huff method, divided the precipitation into four categories, considering the fact that rainfall occurred in which quarter. Rainfall events were investigated separately at 10%, 20% and 100% probabilities using the Weibull formula. Finally, 132 heavy rainfalls were selected and the frequency of precipitation was classified according to the seasons. Finally, they concluded that type 1 rainfall is more frequent after type 2 and that it occurs more frequently in summer. While the third and fourth rains are distributed throughout the year. In summer, rainfall events lasting less than 12 hours are more frequent, while rainfall events are more than 18 hours during the rest of the year. Bustami et al (2012) used rainfall data from 7 rain gauge stations recorded from 1998 to 2006 to study the rainfall temporal distribution pattern in southern Sarawak from 1998 to 2006 using 10, 15, 30, 60, 120, 180, 360-minute templates. They got it. The results show that the southern region of Sarawak has a unique rainfall pattern different from the patterns developed for the Malaysian Peninsula. Zhang et al. (2014) used data from 10 precipitation stations recorded daily over a period of 25 years from 1986 to 2010 to determine the temporal distribution of precipitation in the eastern basin of the Valiang Sai River. The respondents used Moving Average methods (MA) and cumulative deviation charts to conclude that the trend of precipitation has been down for 25 years and the rate of rainfall changes in the new century is high. Ghassabi et al (2016), for the first time in Iran, used the WRF model to determine the temporal distribution pattern of precipitation in southwest Iran and fitted a three-parameter logistic function to the precipitation data. In this study 35 heavy rainfall was selected from the observational data to simulate the WRF model, considering the flow events independently of each other and fitting the best three-parameter logistic equation to each point. The results showed that the coefficient (a) of the logistic equation showing precipitation intensity varies between 14 and 70%. In addition, the precipitation intensity values in southwestern Iran are lower than the SCS recommendation (Ghanbarpour et al., 2001). Raziei and Azizi (2008) study the time distribution pattern of precipitation at 13 rain gauge stations in Tehran province using Pilgrim's Huff probability and computational methods for 1,2,6,12-hour precipitation and report that the maximum amount of precipitation in 1-hour storms. In the first or second quartile, in 2-hour storms, maximum in the second or third quartile, and in the 6 and 12-hour time bases, in the second or third quartile. In this study, the maximum amount of precipitation was reported in the second and third quartiles, and the number of storms with the highest amount of precipitation in the first and fourth quartiles was low, and with the increase of the time base of the rainfall, the peak of rainfall reached the end of the storm. Huff and Pilgrim's results have the same result (Khaksafidi et al., 2012). In order to obtain cumulative rainfall curves and determine a suitable pattern for rainfall temporal distribution, Radmanesh et al. (2005) studied the cumulative rainfall recorded by rain gauges in the southwest of Zagros between 1966 and 1991. The data were first analyzed by homogeneity tests and after initial investigations on the quantity and quality of these data and determination of reliable data, a computer model was developed to determine cumulative rainfall curves. In this model, the cumulative percentage of rainfall height and the cumulative percentage of rainfall time at all the rain gauges were determined. Three cases were considered in this study. In the first step, cumulative rainfall curves for each storm were obtained at all rain gauge stations in the study area. In the next step, a rain gauge station was surveyed in all selected storms and in the third stage these operations were performed simultaneously for all stations in all storms. In each of these three stages, a set of curves with a probability of 10% to 90% is obtained which is essentially the pattern of the temporal distribution of precipitation. Using the model created in this study, cumulative rainfall curves can be used for application in rain-discharge models where there are a good number of stations. Radmanesh et al. (2007) considered 4 stations in order to determine the temporal distribution pattern of precipitation in the Roodzard basin and studied 13 inclusive storms from 1970 to 2002. The results of this study are based on the suggestion of an appropriate time distribution model based on the cumulative mean percentage of rainfall at the common time bases for each of the models as well as another model based on 13 selected storms for the entire catchment. Mollaie and Telvari

(2009) obtained a temporal distribution pattern of precipitation for 4 precipitation stations in Kohgiluyeh and Boyer-Ahmad province using the Pilgrim computation method and concluded that in rainfall with a duration of 1, 2, 3, 9 hours, the maximum amount of precipitation was in the second 25 percent and in the precipitation of 6, 12, 18 hours, the maximum amount of precipitation was in the third 25%, and in the precipitation with 24-hour duration the maximum amount of precipitation occurred in the fourth 25%. The time of continuity shifts toward the end of the duration (25% of the fourth). Asakereh and Razmi Ghalandari (2014) studied the monthly rainfall statistics of 73 stations during the period 1996-2006. They interpolated precipitation data using kriging geostatistical techniques and estimated the mean and coefficients of precipitation on an annual and monthly basis to provide a clear picture of the descriptive characteristics of precipitation and their spatial-temporal variations. To study the temporal distribution of precipitation, uniformity index and seasonal index were calculated and presented for each of the cells of the map, as well as to investigate the temporal distribution of precipitation over the twelve months of the year, and to identify each month's share of the mean annual precipitation, rainfall uniformity index. The results showed that the lowest coefficient of variation and the highest rainfall uniformity occur in the northeast of the study area. This section has a uniform rainfall regime with a wet season indicating that the various rainfall systems are most active in these segments, in contrast to the southwestern part of the zone, with a highly concentrated rainfall regime reflecting the increasing impact of centralized systems in a season. It is about 80% of the zone with seasonal rainfall regime with a short dry season. Jahanbakhsh Asl et al. (2015) used cluster analysis method to investigate temporal and spatial distribution of precipitation in Tabriz city. Cluster analysis is a general term for a series of mathematical methods used to find similarities between materials in a set. The goals of many research activities are to find out the similarity or differentness of the materials in a collection, so the best approach is to use classification. Cluster decomposition methods perform the classification method using mathematical formulas. In addition to clustering, cluster analysis is also used to find similarities and to plan and manage, so cluster analysis is the most common way to estimate similarities between individuals in a cluster. For this purpose, the researchers used daily statistics of 11 stations during the period of 1999-2008. Then, using different statistical methods, they analyzed the temporal and spatial patterns of daily precipitation at city level. zonation the area in terms of precipitation, they first produced daily maps and then converted them to data. The results show that Tabriz is divided into three groups of low, medium and high rainfall.

- **Triangular distribution method**

Another method of determining the time distribution patterns of rainfall is the use of triangular distribution. Triangular hyetograph is a graphical representation of changes in precipitation over time. Yen and Chow (1980) developed more than two hundred and fifty thousand storms recorded throughout the United States to develop a triangular non-dimensional hyetograph and obtain a map of the timing of the peak event for the whole country. They analyzed the storms in the four cities of Illinois, Boston, Massachusetts, and Elizabeth of New Jersey and San Luis in California. Their analysis showed that the above storms were subject to a triangular pattern and the difference was due to changes in rainfall persistence, spatial location, and inaccuracy of some data. Several methods may be used to mathematically describe the temporal distribution of precipitation. The more data is used with shorter periods of time, the more accurate the representation but the more complex the calculations become. Flooding occurs quickly and in a short time, often in just a few hours or half days, and rarely more than one day. The time to reach the peak of the hydrograph may even be less than 10 minutes. The triangular hydrograph is actually assumed to represent the sharp and rapid rise of the hydrograph. The triangular shape of the design flow is suitable for arid and semi-arid regions (Rajah et al, 2014). By moving the rainfall blocks over time, a very diverse set of rainfall patterns can be obtained. Here the basic argument in synthesizing the design rainfall pattern is that the largest rainfall block, the most severe component, can be set at any desired time step. If placed at the beginning of the rainfall, it usually yields the smallest maximum instantaneous flood discharge and, if set at the end of the rainfall period, usually yields the largest maximum instantaneous peak discharge in the associated flood. One method is to place the largest block (the most severe component of precipitation) in the middle, about one second of the total rainfall duration. The other blocks should be positioned around the largest block in such a way that a triangular distribution is obtained, meaning that the intensity of rainfall from the center to both sides (beginning and end of rainfall) is reduced. Using this rule, you can obtain the desired patterns. Chow et al (1988) showed the height of the triangular distribution with h and the rule with Td. Thus the total precipitation is obtained from the Relationship 2.

$$p=0.5\ Td\ h \qquad (2)$$

The height h is also determined by the Relationship 3.

$$h=\frac{2p}{T_d} \qquad (3)$$

Rainfall coefficient (r) in the study of Chow et al (1988) is defined as the proportion of storms before reaching the peak value (the most severe storm component, (ta)) (Relationship 4).

$$r=\frac{t_a}{T_d} \qquad (4)$$

In this study, the duration from the peak to end of a storm is determined from the Relationship 5.

$$t_b=t_d-t_a \qquad (5)$$

With a value r = 0.5 the peak intensity occurs in the middle of the storm. If this coefficient is less than 0.5, the severe component of the thunderstorm occurs before reaching the half-time of the thunderstorm, and if it is greater than 0.5, it occurs after the middle of the entire rainfall period. For a proper estimation of r, it is necessary to calculate the ratio of the time to maximum intensity to the persistence of a storm for a series of storms with different durations. Table (1) presents the r values estimated in different studies by different researchers. The values presented in this table represent approximately less than 0.5 for r indicating that the most severe rainfall component in the study area occurred less than half the duration of the rainfall. According to the results of Chow et al (1988) although the triangular distribution method is appropriate, the time of maximum rainfall intensity can be determined by searching local information and sometimes by the time and weight position of the maximum recorded intensities.

Table 1: Rainfall coefficient values for different regions (Akan and Houghtalen, 2003)

study area	r	Reference
Baltimore	0.399	McPherson(1958)
Chicago	0.375	Keifer and Chu(1957)
Chicago	0.294	McPherson(1958)
Cininnati	0.325	Preul and Papadakis(1973)
Cleveland	0.375	Havens and Emerson(1968)
Gauhati, India	0.416	Bandyopadhyay(1972)
Ontario	0.480	Marsalek(1978)
Philadelphia	0.414	McPherson(1958)

Karimi et al. (2013) used Yen and Chow, Chicago and artificial block methods to obtain a temporal distribution pattern of precipitation in the Babolsar urban basin. For this purpose, by considering 329 continuous rainstorms from the rainfall graphs between 1996 and 1998 and by classifying the rainstorms into 5 categories of less than 6 hours between 6 to 12 hours, 12 to 18 hours, 18 to 24 hours, and larger than 24 hours, the curve categories They plotted the intensity, duration, frequency, and concluded that, if appropriate rainfall data were available, the Yen and Chow method could be used as a suitable method for determining the timing of storm surges at a station or area. Ellouze et al (2009) used an artificial triangular model developed in the Zioud watershed in central Tunisia to produce triangular hygrographs based on statistical analysis of precipitation data. For this purpose, 2799 hourly rainfall data recorded between 1974 and 1991 were used at 10 stations and from these data selected values greater than 4 mm and arranged according to season and duration. Next, we obtain the parameters of the triangular model for each individual storm, and conclude that the dimensionless hygrographs specified are almost identical when used with the dimensionless depth and duration, indicating that seasonal variations and rainfall duration have little effect, as well as There is a good agreement between simulated and observational hyetographs, not only in visual perception but also in statistical and graphical tests.

Conclusion

One of the most important features in the formation of flood hydrographs is the temporal distribution of rainfall. That is, variations in the amount of rainfall over time. Understanding how rainfall is distributed goes back to studying its temporal distribution. They can be used to determine rainfall characteristics when rainfall data are well available. These features are mainly available from the data recorded at the rain gauge stations. However, stations that do not have a rainfall record cannot obtain information other than the total amount of rainfall and its average intensity from a rainfall event. For many design calculations, rainfall data is the most important input. Examples include sewage system design, flood risk assessment, river discharge, and water quality. Due to the large variations in the temporal distribution of precipitation, long-term historical rainfall series should be used for such calculations associated with statistical parameter analysis. Ideally, spatial distribution of rainfall should also be used in these calculations. But spatial variability is more difficult due to the limited data available. Rainfall variability in time and location is a major challenge for hydrological design calculations. Although these changes need to be taken into account, the explanation is often inconsistent with economic realities. Extraction of a single hydrograph in a basin requires simultaneous flood hydrograph and rainfall hydrograph. Access to the hydrograph is possible at the outlet of the basin, and the hydrograph can also be obtained with respect to the rainfall network. It is necessary to obtain a temporal distribution of rainfall in order to produce a rainfall histogram. Although individual rainfall records show temporal variations, these temporal variations also have temporal averages. It is often assumed that the temporal distribution of critical storms for small dams or any other small waterfront is uniform. The temporal distribution of rainfall has a significant effect on the hydrograph but decreases with increasing basin area and is less sensitive to the temporal distribution of floods in high-basin floodplains. In fact, it is assumed that a rainfall pattern can be assumed to be uniform with the given time distribution over the entire basin surface. This assumption does not pose a particular problem for small watersheds, but creates problems for large watersheds. Two solutions have been proposed to solve this problem. First, for example, a 24-hour rainfall converts to a 34-hour rainfall, assuming zero rainfall over a 10-hour period. Now for a basin of 10 hours the precipitation is initially zero, and for the other basin these 10 hours are shifted to the bottom without changing the temporal distribution of the original rainfall. The second solution is to change the temporal pattern so that the peak of the introduced hyetograph for the sub-basins does not enter the basin at the same hour. The estimation of the delay time between rainfall occurrence below the basins and their peak time can be used for the statistics of basin stability stations. Another criterion for the temporal distribution of rainfall is its uniformity index. On a global scale, Toronto in Canada has one of the most uniform rainfall regimes and, on the contrary, Antofagasta in Chile has a very unstable regime. In Iran, Darab has the lowest and Sarkat has the highest uniformity index. In engineering designs, direct runoff hydrograph determination involves several stages. One of the important steps is the time distribution of rainfall. There are various methods for determining the time distribution pattern that are discussed below:

1. Using the Intensity-Duration-Frequency (IDF) method to determine the time distribution pattern
2. Determining the pattern of temporal distribution of precipitation by theoretical method
3. Select one of the available SCS type patterns for the design area
4. Determine the time distribution pattern of precipitation using observational data
5. Australian-American drawing and computational modeling method
6. How to use empirical probability
7. Triangular hydrograph method

The purpose of determining the temporal distribution pattern of precipitation is to obtain a suitable model for the study area. Due to changes in the climate, including changes in the rainfall regime, timely statistical and climatic surveys in each region are essential. Knowledge of the characteristics of rainfall time and its distribution is always needed in various types of hydrological studies for the design and application of water resources systems. Therefore, it is important to choose the appropriate time distribution pattern in each region.

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